ALBERTA EXPORT HOME

with funding provided by

Alberta

DEPARTMENT OF HOUSING

Innovative Housing Grants Program

ALBERTA EXPORT HOME

March, 1985

This project was undertaken by Joseph Skvaril Architect Ltd. and was funded in part by a grant from the Alberta Department of Housing to Atco Industries (NA) Ltd.

The views and conclusions expressed and the recommendations made in this report are entirely those of the author and should not be construed as expressing the opinions of the Alberta Department of Housing.

ISBN 0-88654-122-0

FOREWORD

This study was made possible with funding provided by the Innovative Housing Grants Program of the Alberta Department of Housing. Originally conceived in 1978, the Program is intended to encourage, sponsor, and assist research and development in the fields of housing, site and subdivision design, energy conservation, site servicing and building product development. Generally, the aims of research funded by the Innovative Housing Grants Program are to reduce housing costs, increase the supply of appropriate housing or improve the utility or performance of dwelling units or subdivisions.

The main purpose of funding these studies is to examine the current issues in the field of housing and to develop innovations which offer improvements. Comments and suggestions regarding the information contained in these reports are welcome.

Innovative ideas come from a wide variety of applicants such as builders, developers, consulting firms, industry associations, municipal governments, educational institutions, non-profit groups and individuals. As the type of project and level of resources vary from applicant to applicant, the resulting documents are also varied.

Please send comments and suggestions or requests for further information to:

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ACKNOWLEDGEMENTS

The author wishes to express his thanks to those representatives of the Alberta Government, consulting teams and private corporations who contributed to the success of the ALBERTA EXPORT HOME research project namely:

- Alberta Department of Housing for supporting this project by an Innovative Housing Grant, and also to Mr. M. Rasmusson, Deputy Minister of Housing and Mr. L. Holmen, Director, Research and Development for continuing advice and cooperation in relation to expandable structures since 1978, and Mr. R. Sloat, Manager, and Mr. B. I. Bazley, for their invaluable inputs into this report.

- ATCO Structures for providing Joseph Skvaril Architect Ltd. with manufacturing cost estimates and administration of the Innovative Housing Grant for this project.

- Alberta Department of Economic Development for their advice and cooperation regarding export markets.

- Mr. D. Saunders, President, Saunders & Wiens Ltd. and his team, for fabrication of the structure and assembly of the package, and also for making special arrangements in the company's lumber yard for the demonstration of this project.

- Mr. R. M. Morison, P. Eng., Senior Partner, Lamb McManus Associates Ltd., for his structural engineering advisory services for the expandable structures since 1978.

- Mr. T. W. Smith, P. Eng., President, TWS Engineering Ltd., for alternative electrical engineering designs in the development of expandable structures since 1977.

- Mr. G. A. Kroening, P. Eng., President, Kroening Associates Ltd., for alternative mechanical engineering designs in the development of expandable structures since 1977.

- Mrs. H. Skvaril, B.Sc., Senior Partner, Joseph Skvaril Architects & Planners, for the organization of the demonstration of the Alberta Export Home and administration of the entire project development.

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EXECUTIVE SUMMARY

This report documents the results of the Alberta Export Home Study, a project supported by the Department of Housing of the Alberta Government, under the Innovative Housing Grants Program.

This research project relates to an innovation named the Expandable Structure System which incorporates the manufacturing, packaging and transportation of prefabricated components which are suitable for the construction of a wide variety of structures such as houses, offices, schools, and hospitals. The system is easy to erect on a prepared foundation and on almost any site. The system's expandability enables a home buyer or businessman with limited funds to start modestly and to expand as their financial capabilities improve. The expansion is a quick, simple and economical operation.

The innovative system was invented by Joseph Skvaril and developed by Joseph Skvaril Architect Ltd., and is patented in Canada and the United States, with patents pending in Australia.

Various technical, energy conservation, and expandability features were proven in the domestic market on two previous projects. One was the author's first expandable house in Lamont, Alberta (60 km north-east of Edmonton) in 1979. The other was the construction of a two-stage, two-storey single family residence in Edmonton's Millwoods in 1982. The Phase I - 488 sq. ft. (45.34 sq. m) bungalow was converted into a Phase II - 1,280 sq. ft. (118.91 sq. m) two-storey house.

The purpose of the Export Home project was to demonstrate that, with the use of innovative construction methods, a domestic product such as a house structure can be converted into an attractive export product. This is achieved by minimizing transportation costs to world destinations and maximizing adaptability to satisfy the diverse demands of foreign customers.

The following are the results of this research project:

1. The project has validated the concept of a component building system which can be used to construct a diverse range of building types and sizes and which can be packaged for economic shipment to world markets. Analysis of the structure erection and package assembly processes has contributed to the further advancement of packaging details and has resulted in more economical use of the package unit to transport supplemental components and finishes.

2. The research and design development led to the erection of a demonstration unit and its subsequent dismantling and assembly into a transportable package. The 84.6 sq. m (910 sq. ft.) structure represented half of a three-storey single family home. The resulting package of 3.0 m x 3.2 m x 4.8 m (10'x10'-6"x16') represented only 18% of the original built volume and weighed only 4100 kg (9,040 lbs.). The custom design appearance of the house was achieved by large span interior spaces and three dimensional roof shapes all of which were assembled from simple and readily packable two dimensional prefabricated components.

3. The structure packages have evolved to satisfy three diverse transportation strategies, namely:

   a) Truck Transportation - for which the most economical package is 3.0 m x 3.0 m x 4.8 m (10'x10'x16'). With this system four 84.6 sq. m (910 sq. ft.) starter homes can be transported in four packages on one semi-trailer (see Figure 10, on page 30). The resulting per unit transportation costs are estimated at less than 20% of the cost of transporting one complete modular unit.

   b) Air Transportation - by Hercules aircraft, effectively utilizing the load bay of 2.85 m x 2.55 m x 16.15 m (9'-6"x8'-6"x53'-0") plus a 3.0 m (10') deep storage area of irregular shape.

c) Trans-Ocean Transportation - for transport by ships designed for carrying either bulk load or containers the packages are sized to match the standard container. Example: the dimensions of three custom packages together are 2.4 m (8') high by 2.4 m (8') wide and 4.2 m + 3.6 m + 4.2 m (14'+12'+14') long, which are equal to the dimensions of one container (8'x8'x40') (see Figure 10B on page 30).

The project has shown that this transportable component system can be used to build clear span structures and exportable buildings which are not limited to the modest widths imposed on modular units employing highway, ship, or air transit systems.

It has been demonstrated that the erection and dismantling of structures utilizing this component system is quick and easy.

The assembly of the experimental package has proven that a system of nesting portions of floor/ceiling components or walls into compact packages is highly economical. This method of packaging reduces the volume of a load by 40 - 50 percent.

The indication of potential savings were so strong that a follow-up research was undertaken which indicated a possible further reduction in package volume by 30 - 34 percent.

In conclusion it should be noted that this project has not only proven the technical viability of the component building system and its efficient transportability but has also identified an export potential for this product to the world's markets.

1.0 INTRODUCTION

The Alberta Export Home research project focuses on the development of a new housing product in Alberta and its export potential to world markets.

The product consists of structural building components floors, roofs, and walls with pre-hung doors and windows. While various combinations of components can be selected to accommodate the construction of a wide range of buildings, this demonstration project, consisted of one-half of a large, three-storey, single family residence.

The aim of the project was to develop a product which would increase not only the quantity of building material exported but through the combination of those materials into manufactured components increase the percentage of Alberta content in foreign construction markets.

2.0 MARKETING PROSPECTS FOR WOOD FRAME STRUCTURES

This portion of the report is an abstract on the current status of the world markets with regard to wood frame structures in the housing and general construction industries.

Instead of presenting subjective views or theoretical opinions of marketing experts, the writer has identified a number of conditions to define the background for marketing of rough expandable structure component packages.

The key points are summarized below:

- The demand for unprocessed softwood and plywood is rapidly growing in most countries of the world. Wood structures are very economical and with the use of increasingly advanced methods of treatment for wood, they are becoming popular in most climatic regions of the world. Furthermore, in countries with colder climates such as Korea and Japan, Canadian style wood framed apartments are superior to those made from other materials in terms of energy efficiency.

- Although Canada is one of the few countries which are rich in softwoods, we are being challenged for export markets in both dimensioned lumber and plywood. In lumber, we must compete against the vast and overproducing American industry and relatively inexpensive products such as the pine currently being harvested from New Zealand tree farms. Our traditional plywood markets in Europe and the Pacific Rim are being invaded by producers from Taiwan, Korea, the Philippines, and others whose products are often cheaper and superior to ours.

- With the exception of industrial camps for construction projects throughout the world, the markets for complete Canadian modular and mobile homes units are rapidly shrinking. This is caused, primarily, by the following factors:

a) Foreign commercial and institutional investors and developers are no longer interested in modular structures because their value rapidly depreciates with time. They still like the fact that they are economical, but would rather invest their money in structures of better quality with higher acoustical and energy conservation values.

b) A large number of the Third World countries which produce cheap steel have successfully penetrated the international camp markets with metal products which are competitive in price to the Canadian modular systems.

c) Some highly industrialized countries, such as Italy, which have almost no domestic supply of wood, are importing Canadian softwood and lumber from which they produce inexpensive houses for export. These houses are of better quality than the Canadian mobile homes. During the last three to five years other countries, such as Great Britain (Scotland) and Ireland, have decided to follow this lead.

d) In the United States, manufacturing companies are growing in size, and the manufacturing of structures is increasingly in the hands of prime manufacturers. Franchising of these products by smaller companies is becoming popular and effective in the U.S. markets. Franchising is viewed as the best way to diversify while maintaining efficiency and addressing the increased competitiveness of the U.S. manufacturing industry.

There are other factors which make it difficult to export a complete house or any complete building to those markets which are still, at least to some extent, open to imports.

The construction industries in the booming regions in the world, such as the Pacific Rim, have followed a different path to that of their Canadian counterparts. Japanese and Korean structure manufacturing and building industries are represented mainly by very large companies, many of which are larger than all of Alberta's manufacturers and builders combined. Japanese companies fund complex research activities to increase economy, energy efficiency and product quality while developing more sophisticated structures. This increasing challenge to the Canadian manufacturing industry has to be met.

With the growing competitiveness of the Japanese wood frame manufacturing industry and their sophisticated marketing strategy, it is a realistic concern that the export of any product other than raw material from Canada to Asia may disappear. In this scenario, a significant part of the North American market would be supplied with more economical houses from Japan.

One way to meet this challenge is to increase the competitiveness of the Alberta wood products. We need to introduce new ideas which make our export products more responsive to the specific needs of foreign customers. These concerns constitute a philosophical basis for this project; the Alberta Export Home offers one solution to address those concerns.

3.0 DESIGN AND FABRICATION OF THE STRUCTURE

3.1 General Information

The Alberta Export Home project is part of a continuing research program initiated by Joseph Skvaril Architect Ltd. in 1976 and further developed and financed by that company since then.

The research has been focused on development of a 100% prefabricated component system, an area which has not been fully explored in North America.

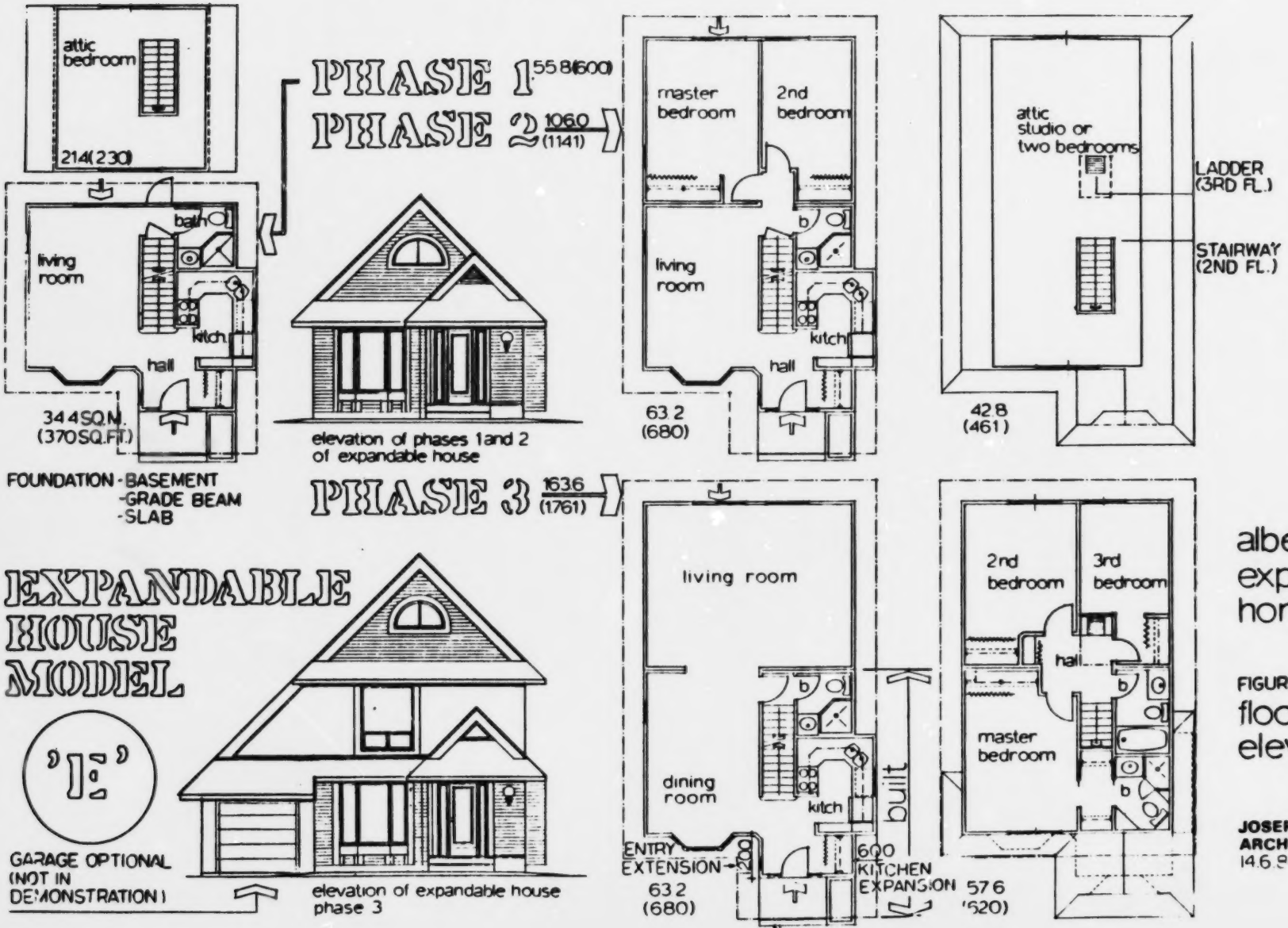
While some Scandinavian construction systems are using prefabricated panels, their application is very costly as a result of the split in labour between the manufacturing plant and the site.

The proposed expandable structure system is based on a concept of maximum standardization for a limited number of components which can be used for the production of an effectively unlimited diversity of housing and building types.

The model selected for construction as the Alberta Export Home was a three-level house, chosen because of its suitability for the Asian and European markets where small lots are common, to achieve a higher density of single family development (see Figure 1, on page 6).

In its final development stage, the size of the house would have been 2,160 sq. ft. (200 sq. m) but because of the repetitive component concept, it was only necessary to construct one-half of the house. As noted, (see Figure 2, on page 7) the space included a well defined entry hall, kitchen, dining room and bathroom on the main (first) floor, two bedrooms on the second floor and a study room for children or another bedroom (typical for Japanese, Korean and Chinese houses) on the third (attic) floor.

FIGURE 1: ALBERTA EXPORT HOME
- Rough expandable structure



alberta export home

FIGURE 2-
floor plans
elevations

JOSEPH SKVARIL ARCHITECT LTD.
14.6.84.

The size of the basic floor/roof component was set at 6000 mm x 4000 mm (20'x16') plus a kitchen addition of 600 mm (2') and an entry addition of 1200 mm (4'). The ultimate developed building area would have been 6000 mm + 600 mm (kitchen expansion) or 20' + 2' in width and 9600 mm + 12000 mm (entry expansion) or 32' + 4' in depth.

The highly articulated design of the 45° roof system enhances the appearance of the house which would create the impression of being a stick-built rather than a prefabricated structure.

A prime goal of the project was not only the standardization of floor, wall and roof components, but also the standardization of all customized exterior components such as roof additions, overhangs, and trim for prefabrication and delivery to the site in the self-contained package.

The major part of the demonstration project was the erection of prototypical house structure and its subsequent dismantling into a self-containing package suitable for transit.

The construction of the Alberta Export Home was subcontracted to Saunders & Wiens Ltd. All prefabricated components were produced on the concrete floor of their warehouse and the house was erected in the outdoor area of their lumber yard. The expandable component package in its transportable form had a total weight of 4200 kg (9,040 lbs.) and was loaded onto a truck by two forklifts.

The superintendent for the house and package construction was Mr. Don Saunders, President of Saunders & Wiens Ltd. His four man crew was untrained in dealing with these products and, in fact, had never worked as a team before. The author supervised the construction of both the house and the package, and was responsible for the organization of this demonstration project.

As the manufacturing of components took place under cover, this phase of the work was unaffected by weather. However, severe winter conditions buffeted the demonstration house during erection and demonstrated one of the benefits of the system. Once the main floor components have been placed on their foundations, L-shaped corner walls govern the position of the filler walls.

As this project dealt only with the production of a prototypical structure and package it was not necessary to incorporate either interior or exterior finishes.

3.2 Project Drawings and Structural Provisions

All shop drawings for the Export Home, except those for truss joists, were prepared by Joseph Skvaril Architect Ltd. with the structural review conducted by Lamb McManus & Associates Ltd. The mechanical engineering was undertaken by Kroening Consultants Ltd. while provisions for the electrical component of the demonstration house were reviewed by TWS Engineering Ltd.

Unlike earlier demonstration houses which had been designed to accommodate residential structural loads, the Alberta Export Home allows for live loads of up to 250 kg/m^2 (50 lbs./sq. ft.) or more. This would facilitate the use of such structures as hospitals, offices, and schools when built in accordance with the regulations of the National and Alberta Building Codes (see Figure 9, on page 28).

3.3 Fabrication of the Components

In this project, the financial limitations did not allow for a demonstration of the production line process. An explanation was provided to the superintendent and his crew on how the components would be manufactured on the production line.

The following summarizes the most important aspects of fabricating the components:

3.3.1 Truss Joists and Floor/Ceiling Components

The truss joists incorporated in the floor components had to be fabricated to exacting design specifications as the location of the intersecting points of the outer surface of the angular end web and the interior surface of the upper chord of the truss joists is important for the assembly of both the structure and the package. The header has to be continuously supported by a girder beam such that once it has taken the load of both halves of the floor members, it becomes a part of the perimeter beam. In this way, the floor which is delivered to the site as two pieces in the package is converted into a rigid unified structural floor component (see Figure 3, on page 11). The task of combining the two separate components and the beam into an integral structural component requires a degree of accuracy which is easy to achieve during the factory production of the various components.

The simulated production line worked very well as attested to by the fact that no problems were encountered in producing the precise angles and dimensions necessary to facilitate the nesting of the split floor components. This showed that a simple and inexpensive metal frame jig which automatically aligns the truss joists and perpendicular headers is all that is needed to achieve the required precision and efficiency in fabrication.

A

B

FIGURE 3: STRUCTURE ASSEMBLY

A - Placement of perimeter beam on L-shaped corner walls
B - Construction of floor at 3rd (attic) level

3.3.2 L-shaped Corner Walls

In this project, the dimensions of the L-shaped corner walls were set at 1220 mm x 620 mm x designed height which, in this case, was 2430 mm (7'x11 5/8"). In production, the outer ends of the two flanges will have laminated posts from 2-38 mm x 89 mm (2"x4") studs but for the demonstration, two studs nailed together were used. Manufacturing of the L-shaped corner walls was carefully supervised as the right angle for both the larger and smaller flange had to be accurate. Even a minor error in the angles would have caused deviation in perpendicularity which would have resulted in further alignment and fit problems in the entire structure.

As a result of the experimental fabrication process, it was determined that a simple jig with right angles in all directions coupled with automatic nailing machines would be the most efficient and economical means of conventional production. The right angle in the bottom plates of the L-shaped wall flanges was fabricated with a diagonal brace which forms an integral part of the sub-floor (see Figure 4, on page 13). The dimensions of the brace were selected for ease of erection and packaging. The location, size and shape of the brace are important to the effective workability of the system.

Because of the structural stability which results from the use of the diagonally braced L-shaped corner walls, it is possible, in detached structures, to replace one corner unit with either a post or a cantilevered load bearing filler panel (see Figure 5, on page 14). In the Alberta Export Home, the right front L-shaped corner was replaced by a cantilevered panel to create the 600 mm (2') kitchen extension noted in the house

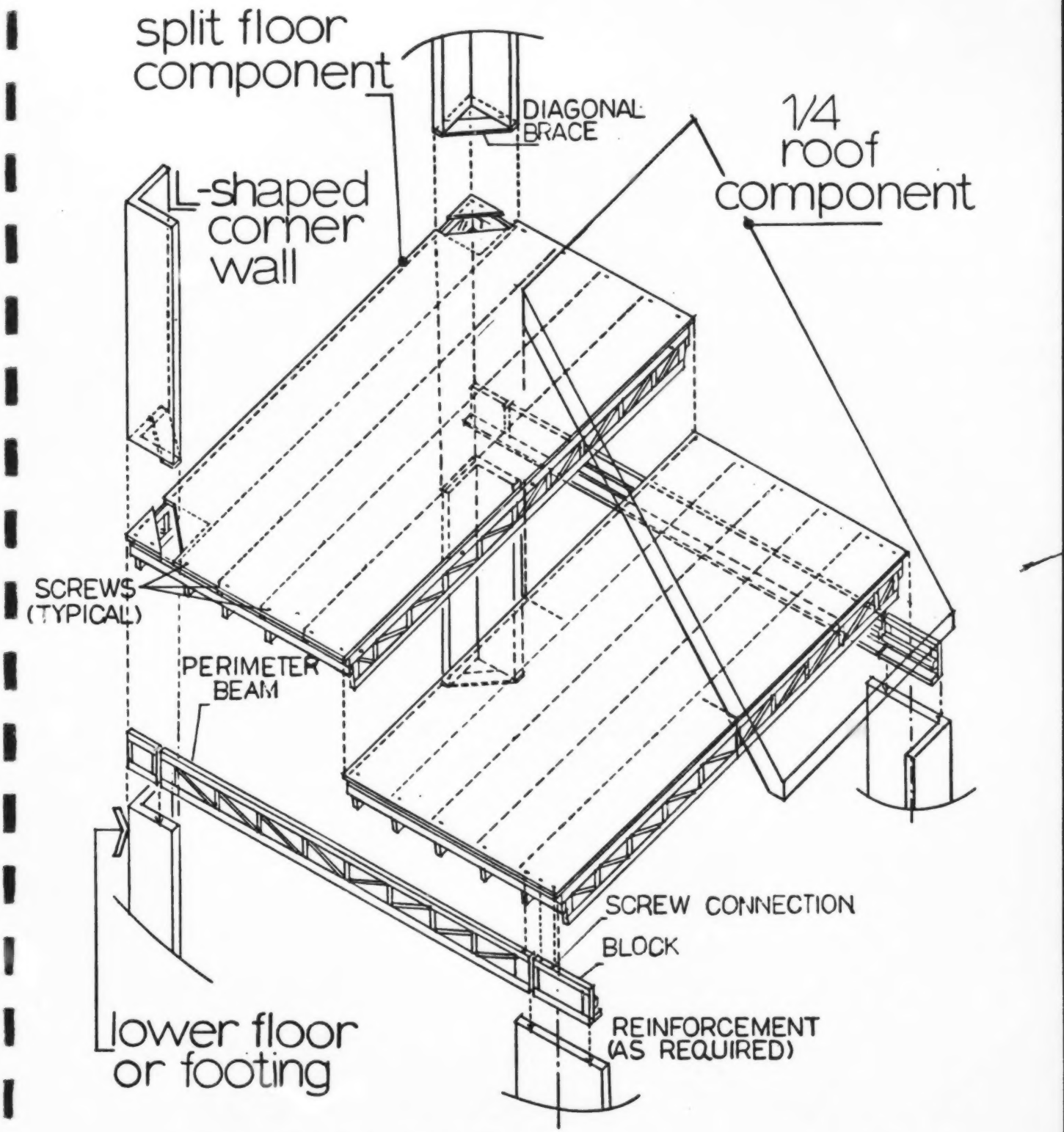


FIGURE 4: STRUCTURAL COMPONENTS
- Split floor and roof assemblies

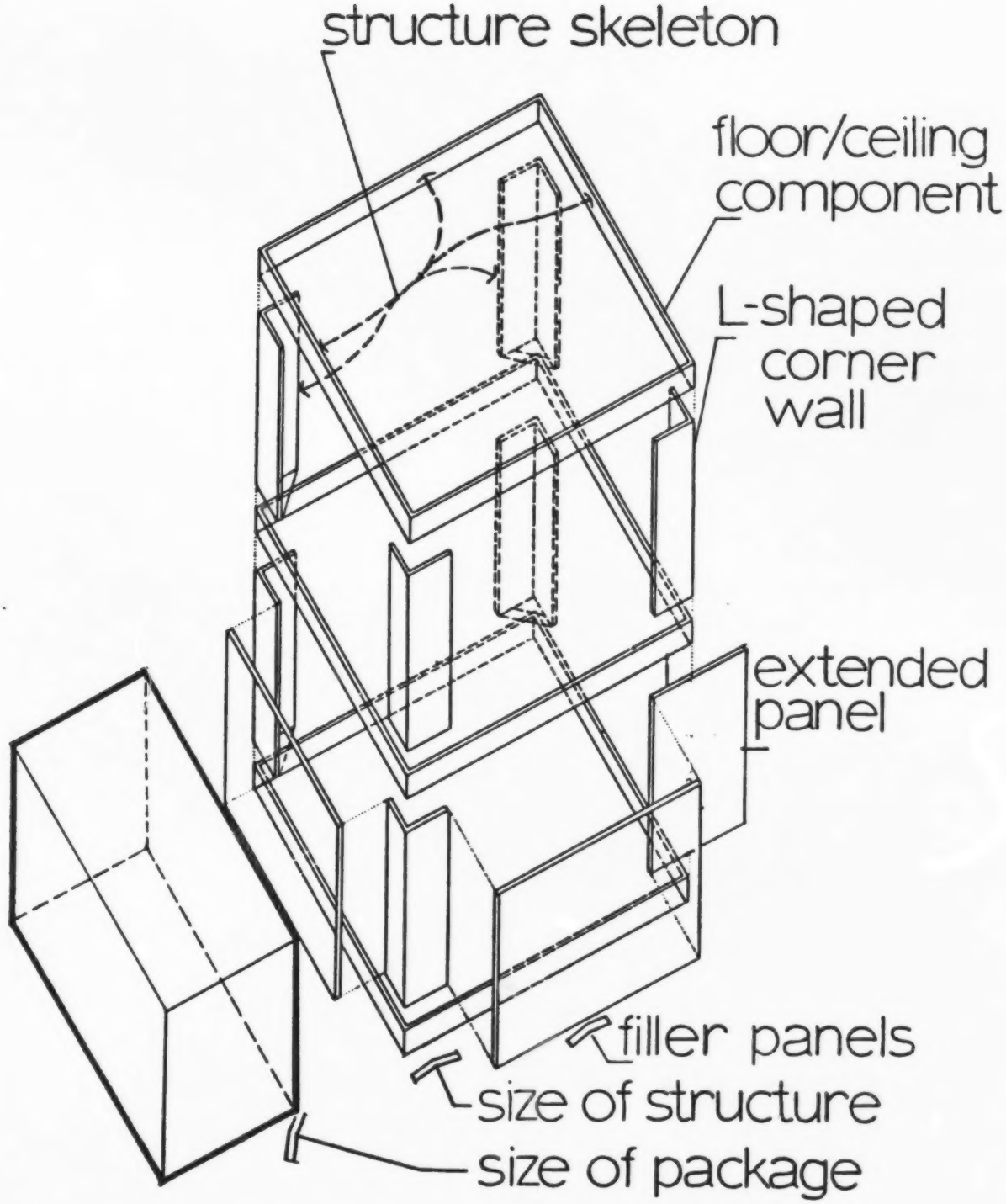


FIGURE 5: SCHEMATIC STRUCTURE
- Noting main components and comparative package size

plan (see Figure 2, on page 7). Under certain circumstances, in multiple unit developments of one or more floors, a load bearing panel may be used in place of two L-shaped corner walls at the joint between two units provided that L-shaped corner walls are utilized in the remaining three corners of each unit.

3.3.3 Standard Roofs

Standard rectangular roof components, regardless of whether they are manufactured from trusses or joists, can be assembled very easily.

3.3.4 Roofs with Customized Details

Customized details such as dormers and overhangs, like roofs, can be constructed from two dimensional components. In the Alberta Export Home this approach was used to create the hip roof overhang at the front entry and the extensive trim at the second and third (attic) floor lines (see Figure 1, on page 6). Whereas, the various detail components require full perimeter framing, their use in any three dimensional configuration produces a double rafter arrangement at all valleys and ridges. The rigidity which derives from this double rafter arrangement can be further enhanced by securing those rafters with 75 mm (3") screws or nails.

3.3.5 Filler Panels

Each filler panel is attached to the perimeter beams at the bottom and top plates. There is no connection between the filler wall and the L-shaped corners. The resultant gap is then used as a "working space" for services and reinforcing in earthquake prone or severe wind areas.

The filler panels are manufactured in two heights:

- The filler panel is the same height as the L-shaped corner wall if the panel is not to be relocated (for example, in future expansion).

- For interchangeable panels, the panel height is reduced by 7.5 mm (3/8") which leaves a clearance between the perimetrical beams and the filler panels. Once the filler panel is positioned in the opening, the space at the top be filled by spare pieces of 7.5 mm (3/8") plywood and caulking, ethafoam, fibre glass, or any other appropriate material.

The length of walls made up from filler panels is dependent on the proposed use of the gaps between the panels and the L-shaped corner walls. If the gaps are to be used only for wiring, the length of the filler wall shall be equal to the distance between the L-shaped walls minus 30 mm (1 1/8"). If however, a vertical reinforcement is to be provided, the 30 mm (1 1/8") tolerance is increased by twice the thickness of the reinforcement (see Figure 6, on page 18).

The cost of the equipment needed for cutting lumber and fabricating walls is modest. This new product can be readily incorporated into any traditional manufactured housing production line.

The flexibility of these expandable structures is relatively unlimited as long as the structural principles of the system are maintained.

4.0 ERECTION OF THE HOUSE STRUCTURE

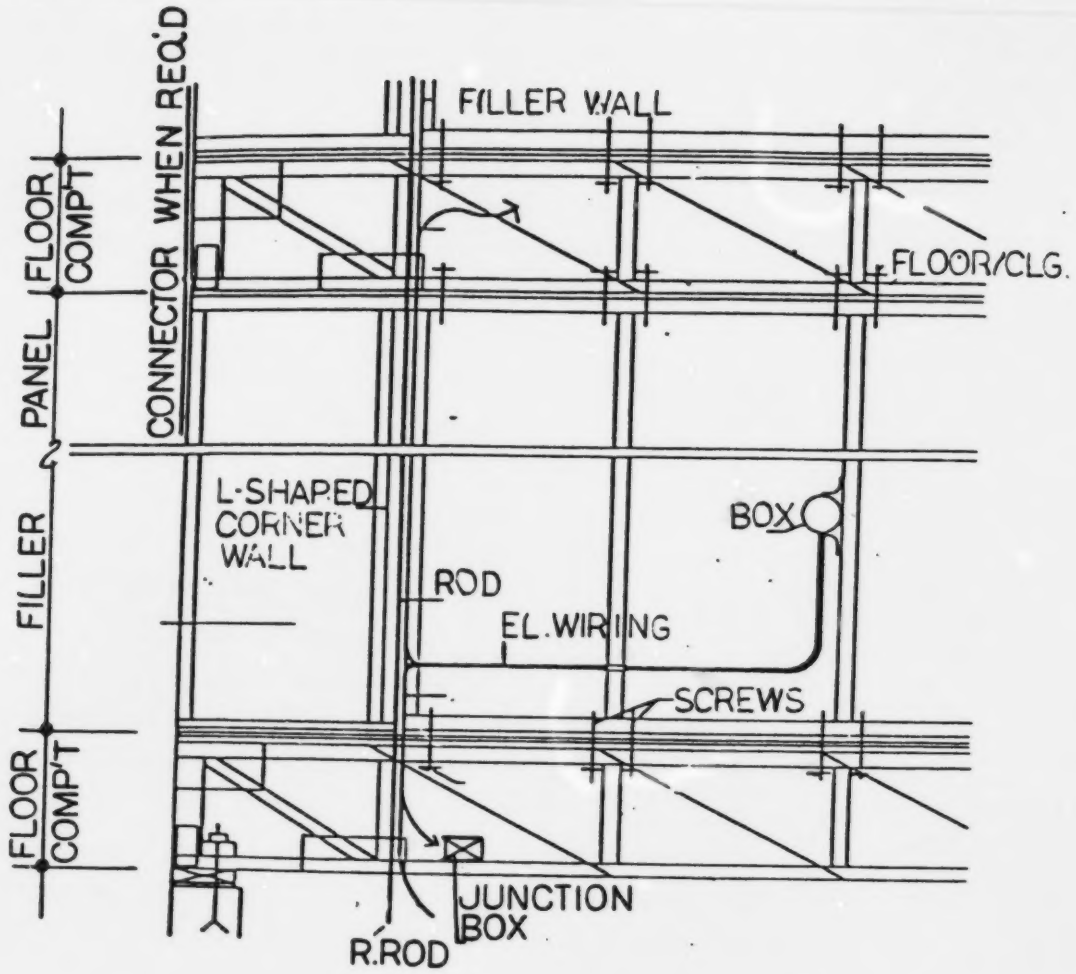
The erection of the structure, its dismantling, packaging of the components, and transportation of the package through Edmonton clearly demonstrated the potential of the concept.

The demonstration house was constructed with 'closed' corner and filler panels, ie. finished on both their interior and exterior faces, in this instance with plywood. This approach allows for electrical services as demonstrated in Figure 6 on page 18. The vertical services are run in the voids between the corner and wall panels and there are provisions for junction boxes at the stud faces. This closed system approach has been developed to facilitate the future expansion, revision, or relocation of finished walls. As well, this system accommodates those instances where factory installation of vapour barriers and drywall is required.

The use of a split panelized roof and floor system minimizes expensive site work. This approach permits the use of the clear spanned attic which would not have been possible with trusses at 600 mm (2') on centre (see Figure 7, on page 19). Custom designed roofs can be easily built using standard components and add-ons whose close construction tolerances are readily achievable in plant manufacture. The attachment of add-ons or decorative elements is relatively easy, because the roof and floor components are essentially hollow plates which facilitate direct attachment to various joists or the use of brackets and connectors.

The demonstration project showed that even with primitive manufacturing facilities, an untrained crew, and an untried product it was possible to build an acceptable prototype. If in future, computer assisted design was integrated with a computerized manufacturing plant, it may be possible to achieve high productivity and competitive unit prices. Further, it is felt that

A - Elevation



B - Plan

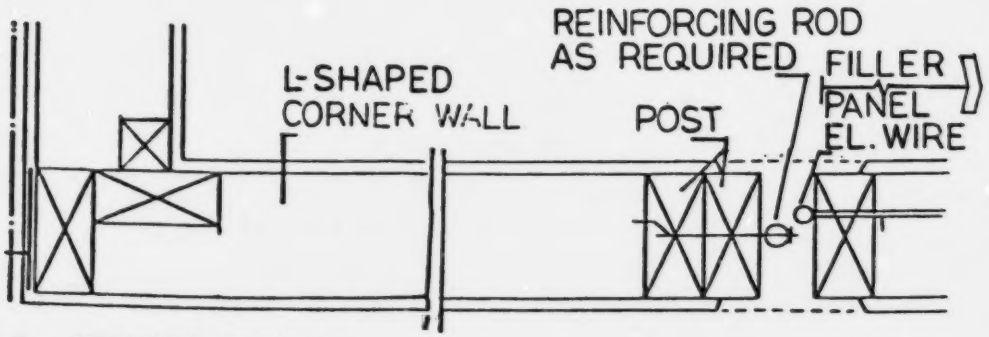
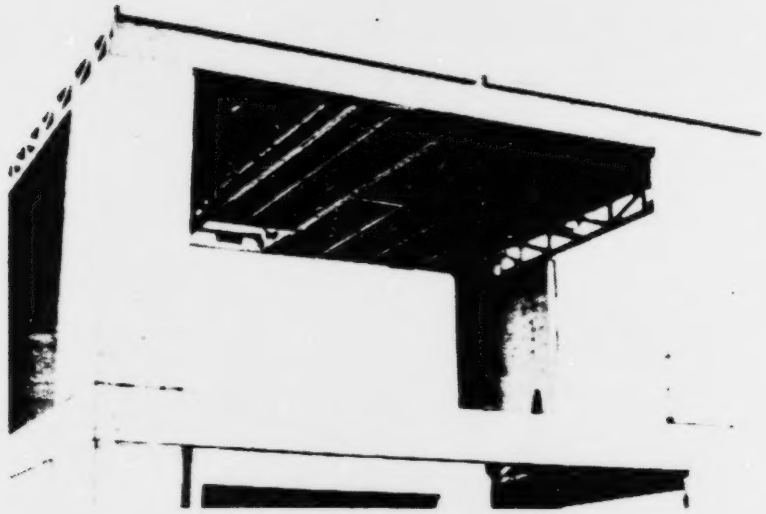


FIGURE 6: STRUCTURAL DETAILS

A - Wiring connections between filler panels and structure
B - Services and reinforcement in gap at joint between L-shaped corners and filler panels

A



B

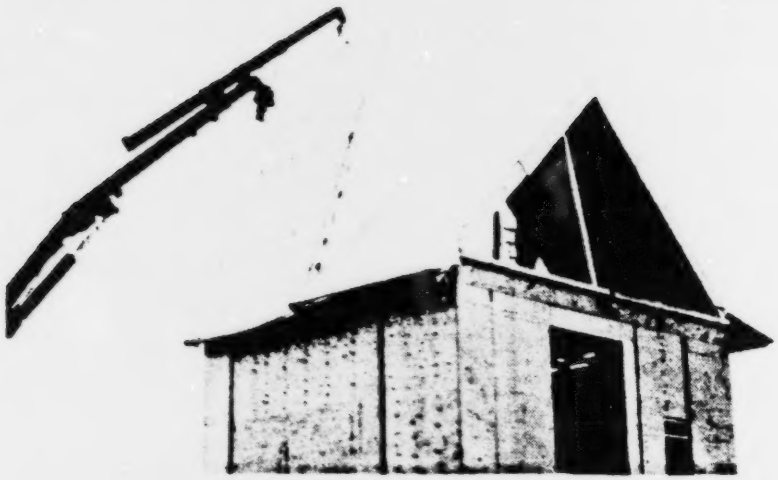


FIGURE 7: ERECTION OF ROOF

A - Attic floor
B - Positioning of 1/4 roof panel
(note: clear-span attic space)

the application of colour coding and labelling components could improve erection times and lower site-costs. If these advantages could be coupled to an efficient transportation system, the potential exists for a viable export product.

5.0 ASSEMBLY OF THE ALBERTA EXPORT HOME PACKAGE

One objective of the Alberta Export Home was to develop a compact self-contained package as a means of making the export of rough expandable structures economically feasible. The volume of the package is 18% that of the erected house (see Figure 5, on page 14).

The package consists of four basic elements.

i) Floor/ceiling components the size of which cannot exceed the horizontal dimension of the package which, in this case, was 4800 mm (16') x 3000 mm (10'). Normally the maximum floor dimension is twice the full wall heights (see Figure 8, on page 22).

ii) Roof components which are similar to the floor/ceiling components.

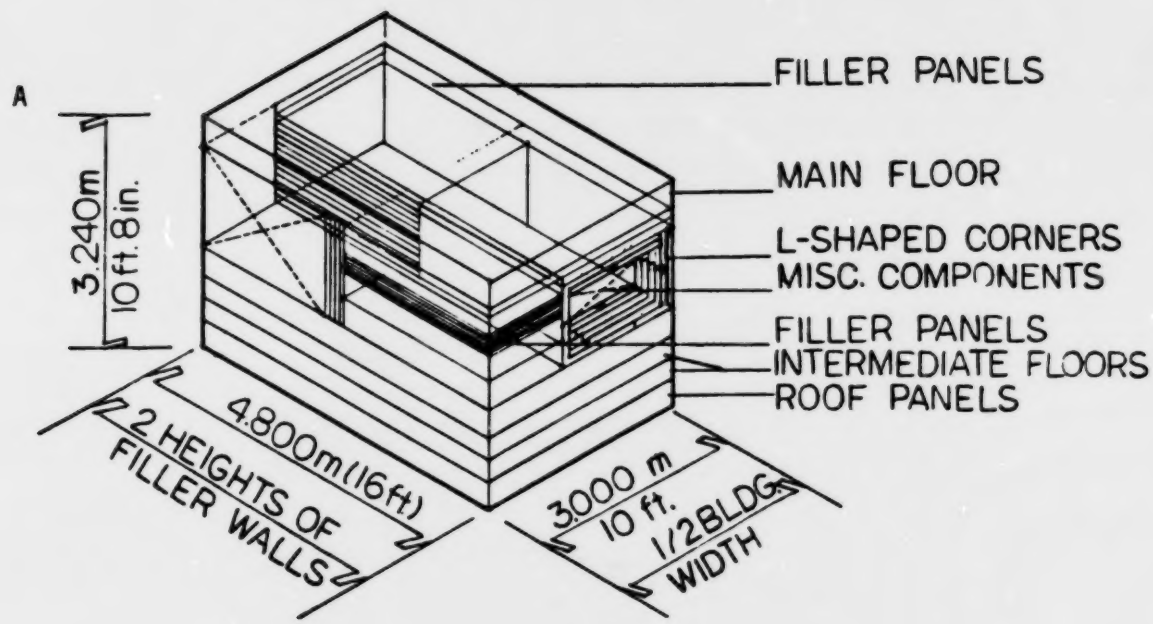
iii) L-shaped corner walls which cannot exceed 1200 mm by 1800 mm by 2400 mm to 3000 mm (4' by 6' by 8' to 10') in height.

iv) Exterior filler walls and interior partitions. The maximum size of these parts in this package was 3000 mm by 2400 mm to 3000 mm or (10' by 8' to 10') in height (see Figure 8, on page 22).

Prefabricated stairs and stair headers can be stored in the stairway opening of the floor components with the headers being positioned during the installation of the stairs.

All girder beams, blocks, braces, handrails, mouldings, insulation, pipes, registers, etc. can be stored between the truss joists of the floor/ceiling components. Decorative roof components, special finishes, hardware and the tools required for erection can be stored in the remaining package voids.

A



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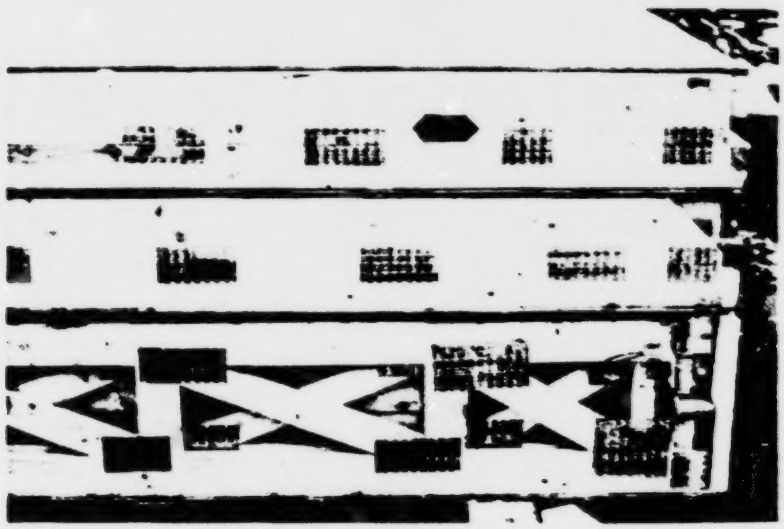


FIGURE 8: PACKAGE OF STRUCTURE COMPONENTS

A - Schematic drawing of the structure component package
B - Packaging of floor/ceiling components

The package can also accommodate the necessary hardware and tools required for the erection purposes.

Color coding could be used to simplify the erection process. Stickers could be applied to explain, through the use of diagram or a simple description how to assemble the structure. There is no need for traditional plans and contract documents and from a technical viewpoint a coding system is easy to implement.

The rough expandable structure component package can be likened to a "mini plant" from which a larger structure can be easily erected using only manual labour. This is especially important in those areas of the world where sophisticated tools or "know how" are unavailable.

The package assembly process is relatively simple:

The floor and roof components of the demonstration home were fabricated in two halves; consequently, it was possible to invert one half of a floor or roof component and internest it with the remaining half thus creating a rigid layer within the package (see Figure 8, on page 22). The rigidity of such internested layers can be further enhanced by screwing or nailing through the floor of the upper half-component into the upturned joist or truss of the lower half-component. These screws or nails will, in production, be colour coded to identify them for early removal. By creating such rigid layers at the base, from roof components; within the package, from attic and second floor components; and on top, from the main floor components, the package is provided a high degree of lateral stability.

- Packaging of the L-shaped corners is simplified because they create a self-locking package system at the bottom plates as noted in Figure 8A, on page 22. The top plates should be

secured by a 19 mm x 89 mm (1"x4") lateral brace to maintain their right angle. The remaining hollow space inside the package of the L-shaped corner walls is ideal for storing fragile plumbing fixtures, electrical fixtures, and finishing materials.

In this innovative system, packaging of exterior wall filler panels is simplified because the dimensions of the panels are standardized. For example, the lengths of the filler panels of the Alberta Export Home were 3000 mm (10') and 1200 mm (4'), with the exception of the cantilevered panels which were 1800 mm (6'). The module dimensions for walls and packages are interrelated.

The rigidity of the package is enhanced in two ways:

- by securing horizontal components together from the inside of the package during its assembly as noted above; and

- by securing 13.5 mm (1/2") plywood sheets to the exterior of the completed package.

What has been described was not difficult to complete and the packaging of the Alberta Export Home proceeded quickly. Some minor delays which occured were caused by the lack of appropriate tools for measuring the verticality of the package. In factory production, this will be done automatically on the production line as manual checks of the squareness of the package are both inefficient and inaccurate.

The most effective procedure for forming properly squared packages is to use metal jigs. The four corners of the jig would contain and control the package assembly process. It is not important whether the interior vertical spaces between different components such as walls are small or large. It is, however, essential to maintain the verticality of the corners. Moreover, vertical

spaces can be easily filled in with wood siding or finishing materials. If further strengthening of the construction of the package is necessary for any special reason, such as ocean shipment, filler blocks may be installed in voids as required.

The packaging should also facilitate the erection. This means that the main floor components should always be placed at the top of the package because they are used first, conversely roofs should be placed at the bottom of the package.

With the degree of standardization of the components and the flexibility of this patented system; the design, production, and package assembly may be integrated into a master controlling computer program. Both the manufacturing and packaging process and the design could be easily interrelated in a computer program.

6.0 MARKETING FEATURES OF EXPANDABLE STRUCTURES

In October 1984, the construction of the Alberta Export Home demonstrated a complex and interrelated component building system which addressed the diverse design requirements of both efficient construction and economical transportation. Sectional and nesting floor and roof components permit large clear span interiors while staying within the restrictive dimensional limitations imposed by highway transit. Innovative connectors and manageable components lend themselves to a simplified erection process.

The most appealing marketing features demonstrated in the Alberta Export Home are listed below:

- Expandable structures of any size and shape can be economically transported in a self-containing package of premanufactured components. The volume of these packages is 18% of the volume of the erected structures (see Figure 5, on page 14).

- Structures can be erected from the shipping package in a matter of hours.

- Small structures built according to the system can be readily expanded in both horizontal and vertical directions in a matter of hours.

- When expansion takes place, existing components can be re-used.

- Three-dimensional custom details; mansard roofs, dormers, et cetera can be easily fabricated from two-dimensional components. Whereas, these components are similar to the floor sections and wall panels, they can be readily integrated into the self-containing package.

- Both the erection and expansion of any structure can be completed in the absence of plan documentation on the site. A pocket-size sketch showing the wall layout and component coding is sufficient for the assembly of any building.

- Illustrative labels on the structural components can explain to any semi-skilled person how to connect the structural members.

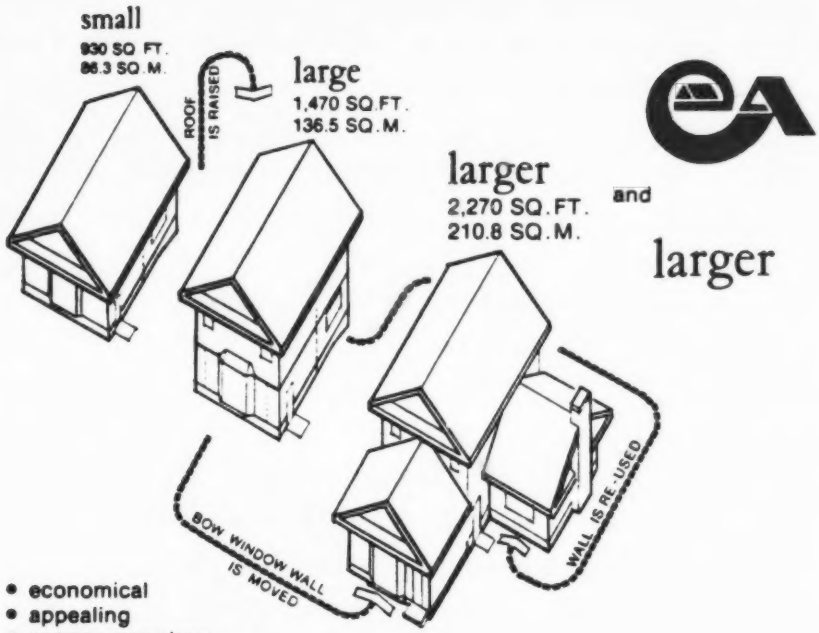
- Factory manufacture of the components for a complete structure simplifies quality control and ensures the highest possible standards.

- The Alberta Export Home demonstrates that a well designed, 100% factory produced structure, does not need to exhibit the box-like look of most contemporary manufactured units.

- Flexibility in the use of standardized components for customized structures minimizes inventory which in turn minimizes the prices of the structures.

- Prefabricated expandable structure component packages, which can be easily erected anywhere in the world, offer great opportunities to export a manufactured Canadian product (see Figure 9, on page 28). This is much better than exporting unprocessed forest products.

- The proposed product introduces a new and effective method of providing higher quality and more affordable housing for both Canadian and foreign customers.



- economical
- appealing
- energy conscious
- high structural quality
- easy to produce, transport and erect

new prefabricated component structures

HOUSES, MOTELS, HOSPITALS, SCHOOLS, OFFICES AND OTHER STRUCTURES

can be built on reinforced concrete basements, grade beams, slabs, expandable preserved wood foundations or other means of sound building support.

This innovative method of developing structures of all types, shapes and sizes integrates advantages of on-site building and prefabrication. The savings achieved by prefabrication of a very limited number of types of complete wall and floor/ceiling components used for various building models are not lost in overhead costs. The production line is very inexpensive and economical in operation. It can be easily assembled or dismantled.

To build small and expand later means a breakthrough in managing both family and national economies. For example, if a starter family buys a small house and saves the difference in loan repayment between this small and an average-sized house, the savings would cover the cost of an addition in two years or less. If they again save the difference in mortgage repayment, in a further two or three years, the amount saved would cover the cost of the second storey. In four or five years the starter family becomes the owner of a large house, while the amount of mortgage loan is 2.5 times less than it would have been by buying the larger house five years earlier.

FIGURE 9: PROMOTIONAL BROCHURE (Example)

7.0 RECENT DEVELOPMENTS

The completion of this demonstration project has resulted in invaluable experience and strong indications that further improvements to the packaging system are possible. These improvements could result in further reduction in the package volume and subsequent savings in transportation costs. Continuing design and detailing efforts have been focused on minimizing the volume and dimensions of the package. To match those of a standard container and to increase compactness, floor components have been split into three segments and the lengths of walls adjusted to containerized proportions.

These recent developments have created a framework for defining the economic implications of transporting expandable structures to overseas markets.

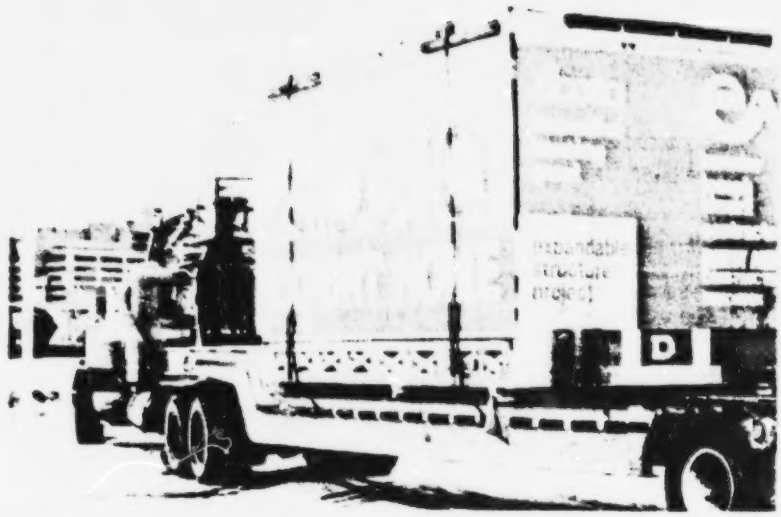
The results are:

a) Packages designed for self-containerized transportation appear to be the most economical. The average volume of the package of all components necessary for the erection of either a motel or apartment block is usually 13% to 14% of the volume of the finished structure. This is based on the assumption that at least one plumbing core is premanufactured and transported as part of the package (see Figure 10, on page 30).

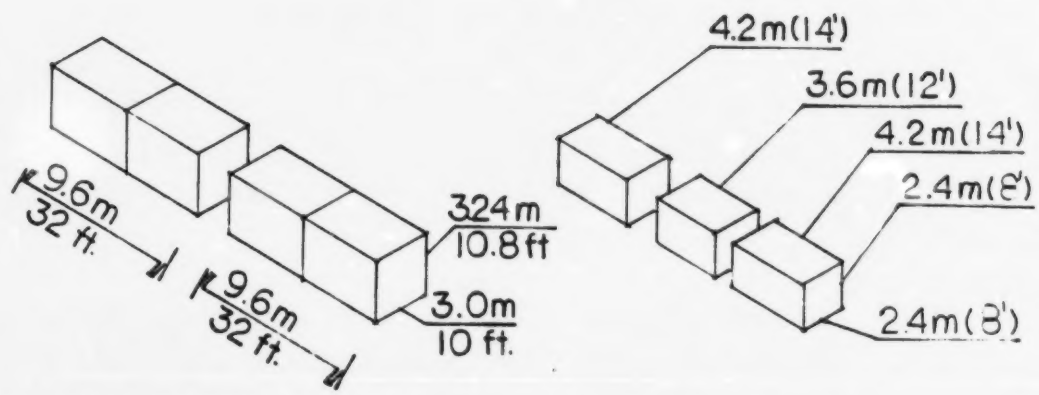
b) Three emergency shelter units can be accommodated in packages equal in volume to a standard container which is 2.4 m x 2.4 m x 12 m (8'x8'x40'). The volume of the package is only 9% of the volume of the completed houses.

In light of the above, it was possible to assume that the transportation costs for shipment of this new export product from Alberta to any destination in the world would be reduced over that of conventional modules. The cost should not exceed $25.00 to $30.00 per sq. m of structure.

A



B



GROUND TRANSPORTATION

CONTAINERIZED (SHIP) TRANSPORTATION

FIGURE 10: PACKAGE TRANSPORTATION

A - Demonstration package on transporter
B - Schematic of packages for transport

Until recently, the transportation costs for the delivery of an ordinary, knocked-down wall module to other countries equaled a substantial proportion of the product value. The fact that transportation of the expandable structure components in the package is so low, below 20% of the value of the product, should make this new system highly competitive with others on the world market.

8.0 CONCLUSIONS

This report has briefly described the erection of the rough structure for the Alberta Export Home and the dismantling and assembly of its shipping package. The report also focused on innovations which could increase the efficiency of the system and improve its economical transportation to potential markets.

The following conclusions summarize the achievements of the demonstration project and indicate how the research findings will be applied in practice.

The key points are:

1. The testing of the erection and packaging of the expandable structure was successful. The practical implications of this are significant, the size and shape of manufactured house plans are no longer limited to the traditional 4200 mm (14') or 3600 mm (12') modules derived from the maximum load widths permitted on Canadian highways. Consequently, the expandable structure need no longer look like factory produced housing despite the fact that all of the components are manufactured. This substantially increases the marketability of these prefabricated expandable structures compared to modular systems.

2. Expandability of these structures becomes a very attractive feature to those buyers who wish to start with a small or average sized residence and undertake expansion once their financial circumstances improve. This is made possible by the use of prefabricated components to create a custom designed exterior appearance in both the starter and expanded models.

3. The size and shape of the L-shaped corner wall and the design of the diagonal brace allows for the safe erection of the structure from the prefabricated components without

necessitating the normal checks of structure verticality or building dimensions. Consequently, a crew which is untrained in the process of erecting or packaging these expandable structures can readily perform a very satisfactory job after having been given only brief verbal instructions. This makes this system particularly attractive to those markets with unskilled labour.

4. The potential for the reinforcement of the structures through the use of steel, wood, or plastic ties and braces can substantially broaden the use of these expandable structures in those countries which experience periodic earthquakes or severe winds.

5. The efficiency of production which is achievable with the plant production of housing components could result in a 20% reduction in the overall cost of providing a house in Alberta.

6. The innovative packaging system will result in savings of 70% to 80% in ocean shipping costs or 75% to 80% in ground transportation costs as compared to the transportation costs for complete modular units.

7. The simple equipment necessary for the manufacturing of the building components can be easily shipped to diverse locations; consequently, the technology and means-of-production can be considered as further export products.

This new Alberta product represents a tremendous opportunity for the export of products manufactured from local material and employing local sources of labour. This is better than relying on our conventional role as suppliers of unprocessed raw materials.

APPENDIX 1

Skvaril Joseph: Canadian Patent No. 1018719.
Prefabricated Cube Construction System for Housing and Civic Development, 1977.

Skvaril Joseph: United States Patent No. 4,441,286.
Prefabricated Cube Construction System for Housing and Civic Development, 1984.

Skvaril Joseph: Australian Patent Application No. 24023/84.
Prefabricated Cube Construction System for Housing and Civic Development, 1984.